ERYTHRISM IN THE SMOOTH SNAKE, *Coronella austriaca* (LAURENTI, 1768), RECORDED FROM GEORGIA

Zdeněk Mačát,[1] David Hegner,[2] and Daniel Jablonski[3]

Submitted June 23, 2015.

Color aberration are frequently known in snakes, however erythrism is one of the rarest. In this paper, we report the capture of one erythristic male of *Coronella austriaca* from Georgia and we also present actual knowledge about color aberration in this species.

Keywords: color aberration; Colubridae; *Coronella austriaca*; Caucasus.

Three classes of chromatophores have impact upon coloration of reptiles (Bechtel, 1995; Vitt and Caldwell, 2013): melanophores (brown to black pigment cells), iridiophores (produce the shiny iridescent and reflecting skin) and xanthophores (yellow and red pigment cells). Different types of color aberrations are slightly widespread between all animal groups, usually results of gene mutations in development or uncommon distribution of chromatophores in the skin (Bechtel, 1995). In reptiles, eight different types of color aberrations have been described; most common are albinism, leucism or melanism and rare are amelanism, axanthism, erythrism, hypomelanism or piebaldism (Bechtel, 1995) although their nomenclature is not consensual.

One of the most frequent color aberrations is melanism, very common and often referred especially in snakes (e.g., Andrén and Nilson, 1981; Shine and Madsen, 1994). It represents a large amount of black coloring at the expense of other colors (Majerus, 1998). The melanistic individuals enjoy a thermal advantage due to their superior thermoregulatory capabilities afforded by dark color of body. On the other hand, they also suffer from higher predation pressure (Andrén and Nilson, 1981; Tanaka, 2009). In European species of Colubridae, melanism has been recorded in *Coronella austriaca* (Pernetta and Reading, 2009), *Natrix natrix* (e.g., Opatrný, 1974; Jandzík, 2004; Naumov and Tomović, 2005; Mollov, 2012; Gvozdenović and Schweiger, 2014), *N. tessellata* (Laňka, 1978; Gvozdenović and Schweiger, 2014), or *Zamenis longissimus* (Zadravec and Lauš, 2011). One species, *Hierophis carbonarius* (also known as former subspecies of *H. viridiflavus* in traditional taxonomy, see Mezzasalma et al. 2015)), is naturally melanistic in adult age stage (Arnold and Ovenden, 2002). Cases of albinism and leucism are also common color anomalies, but survival rate of individuals in nature is probably low (e.g., Bechtel and Bechtel, 1981; Krecsák, 2008). It is presenting as a white (yellowish/pinkish) body with red or dark eyes (Bechtel, 1995). These anomalies have been recorded e.g., in *Natrix maura* (Pérez and Collado, 1975), *N. natrix* (e.g., Boulenger, 1913; Musilová et al., 2006), *N. tessellata* (Werner, 1898; Boulenger, 1913), *C. austriaca* (Werner, 1898; Rehák, 1992, Moravec, 2015), *C. girondica* (Martínez-Silvestre et al., 2009), *Rhinechis scalaris* (Menjón, 2011) or *Z. longissimus* (Erber, 1879; Balthasar, 1935; Ferri and Bettiga, 1992). Other types of color aberrations at snakes in general (axanthism or piebaldism) are probably rare, with only several recorded reports in available literature (Stegenga and Mohr, 2012; Kornilios, 2014).

As one of the rarest aberration at Palaearctic snakes is erythrism. It is defined as naturally occurring color condition of animals with excessive production and deposition of red and orange pigments (erythrophores) with various shades and degrees of intensity (Gilhen, 2010; Moore and Ouellet, 2014). Among the European snakes population, erythrism is very rare. However, in vipers are known reddish or orange populations; *Vipera berus*, so called aberration *chersea* Linnaeus, 1758 or *V. ammodytes* from Montenegro and northern Albania (Kreiner, 2007; Fric and Moravec, 2015). The one old record of erythristic *Z. longissimus* from Slovakia is also known (Lác, 1970).

[1] Department of Ecology and Environmental Sciences, Palacký University in Olomouc, Šlechtitelů 27, 783 71, Olomouc, Czech Republic; e-mail: zdenek.macat@gmail.com

[2] Mšenská 3938/26, 466 04 Jablonec nad Nisou, Czech Republic.

[3] Department of Zoology, Comenius University in Bratislava, Mlynská dolina B-1, 842 15, Bratislava, Slovakia; e-mail: daniel.jablonski@balcanica.cz

Fig. 1. The erythristic *Coronella austriaca*: *a*, dorsal side; *b*, ventral side.

The smooth snake (*Coronella austriaca*) is western Palaearctic colubrid species, commonly widespread from Portugal, Spain on a west to Iran, Kazakhstan and central Russia to the east (Arnold and Ovenden, 2002; Sindaco et al., 2013) with several independent phylogenetic lineages occurring there (Galarza et al., 2015; Sztencel-Jabłonka et al., 2015). According to Arnold and Ovenden (2002), coloration in *C. austriaca* is considerably variable, but usually grayish, brownish and pinkish. Males are usually brighter than females and color pattern in adults occasionally shows some correlation with habitat. Back is colored with small dark spots, head with dark blotch often crossing to two short dark stripes on the neck. Dark stripe from side of neck through eye to nostril is also present. Belly is usually darkish (red, orange or gray). Juveniles are more contrast than the adults, abdomen is often in brick red color.

One adult male of erythristic *C. austriaca* (Fig. 1) was captured on 30 April 2013 in surroundings of village Meneso (Mccheta-Mtianetie, Georgia; 42°15′11″ N 44°40′26″ E, 1003 m a.s.l.) in Agravi river valley. Individual was found during cloudy weather without rain on river rocky shore terrain. The animal dorsal surface was reddish/brownish (Fig. 1*a*). Usual coloration patterns (head blotch and stripes, nostril-neck stripes) were only slightly visible. All these structures were reddish and darker than rest of body. Belly was slightly orange. Other recorded reptilian species at the locality were *Lacerta strigata* Eichwald, 1831 and *Darevskia rudis* (Bedriaga, 1886). No other records of erythristic individuals of *C. austriaca* are known from literature, however Rehák (1992) referred about numerous reddish specimens of *C. austriaca* (without any details) recorded in northeastern Turkey and Azerbaijan. Besides erythrism, several other color aberrations have been recorded in *C. austriaca* (see Table 1).

To our best knowledge, this is probably the first published and photographed record of erythrism in *C. austriaca* from Georgia, overall uncommon phenomenon in snakes. There are no more data about benefits in selective mechanisms or thermoregulation of erythrism in snakes (Mooi et al., 2011). Red coloration could serve as an aposematic coloration (Gotmark, 1994) or option of defensive behavior like Batesian mimicry (Cassell and Jones, 2005). However, there is number of snake species that use red coloration as easily recognizable characteristic and as a result they deceive a potential predator (e.g., *Diadophis*, *Lampropeltis*). Red coloration brings certain advantages; e.g., experiments with salamanders (*Plethodon cinereus*) showed that birds selectively avoid attacking erythristic individuals than normally colored (Tilley et al., 1982). Similar results were confirmed in red-striped morph of *P. cinereus* (Venesky and Anthony, 2007). Therefore, a single but significant evolutionary event as predation pressure could probably evolve the matching colors or patterns in common ancestor of some group of snakes. Indeed, many snake species with red coloration of its body (some members of genus *Atractus*, *Cylindrophis*, *Helicops*, *Oxyrhopus*, *Tripanurgos*, juvenile of *Clelia clelia*, *Oreocryptophis*, etc.) live in the tropics where the predation pressure is potentially higher.

However, also other explanations in connection of red color may be discussed. For instance, Fitch (2001) proposed a link between red color and aggressive behavior. According to Thurow (1955), rather genetics is involved in erythristic form than environmental factors. This phenotype could result from the action of mutant allele that quantitatively inhibits the development of melanin (Thurow, 1955). Other explanation offer Mooi et al. (2011), who suggested that color aberration is influenced by local evolutionary forces like position of glacial refuges of the species. According to current results based on mtDNA analysis (Galarza et al., 2015; Sztencel-

TABLE 1. A Summary of Color Variation Occurrence in *Coronella austriaca* (ind. — individuals, F — female, M — male).

Aberration	Locality	Sex, *N*	References
Melanism	—	—	Boulenger, 1913
	Folgoso do Courel, Spain	—, 1 ind.	Castroviejo, 1971 in Meijide and Peréz-Melero, 1994
	Oceño, Spain	M, 1 ind.	Hopkins, 1976
	Panes, Spain	juvenile, 1 ind.	Meijide and Peréz-Melero, 1994
	Burbia, Spain	adult, 1 ind.	Barbadillo et al., 1997
	Dorset, United Kingdom	MM, 2 ind.	Pernetta and Reading, 2009
Albinism	—	—, 1 ind.	Werner, 1893
	—	—	Boulenger, 1913
	Meinweggebied, Netherlands	adult, 1 ind.	Lenders, 1989
	Tábor, Czech Republic	F, 1ind.	Rehák, 1992
	Magdalensberg, Austria	juvenile, 1 ind.	Happ, 1994
	Meinweggebied, Netherlands	juvenile, 1 ind.	Lenders, 2008
Erythrism	Turkey, Azerbaijan	—	Rehák, 1992
Lutinism/Leucism	Domažlice, Czech Republic	adult, 1 ind.	Niebergall, 2008
Hypomelanism	Tijarica Donja, Croatia	adult, 1 ind.	Lauš and Burić, 2012
Anerythrism	Stubičke Toplice, Croatia	adult, 1 ind.	Lauš and Burić, 2012
Hypoxantism	Štramberk, Czech Republic	M, 1 ind.	Moravec, 2015

Jabłonka et al., 2015), independent phylogenetic lineage of *C. austriaca* occurs in region of Caucasus what may speculatively correspond with specific morphological characteristics of the local population. In any event, an adaptive evolution of color aberrations in snakes as well as facts about red coloration phenomenon are underestimated and other experimental research is needed.

Acknowledgments. We are grateful to Martin Rulík (Olomouc, Czech Republic) for revision of first version of the manuscript draft and to Boris Lauš (Zagreb, Croatia) and Xavier Santos Santiró (Barcelona, Spain) for providing literature. Zdeněk Mačát was supported by IGA PřF UPOL: No. IGA_PrF_2015_008.

REFERENCES

Andrén C. and Nilson G. (1981), "Reproductive success and risk of predation in normal and melanistic colour morphs of the adder, *Vipera berus*," *Biol. J. Linn. Soc.*, **15**, 235 – 246.

Arnold E. N. and Ovenden D. (2002), *A Field Guide to the Reptiles and Amphibians of Britain and Europe*, Collins, London.

Balthasar V. (1935), "Několik pozoruhodných objektů herpetologické sbírky Slovenského vlastivědného musea v Bratislavě," *Věda přírodní*, **16**, 67 – 68.

Barbadillo L. J., Veldormorog D. G., and Sánchez-Herráiz M. J. (1997), "*Coronella austriaca* melánica depredando sobre *Lacerta monticola cantabrica* en el norte de la Península Ibérica (Burbia, León)," *Bol. Asoc. Herpetol. Esp.*, **8**, 31 – 33.

Bechtel H. B. (1995), *Reptile and Amphibian Variants*: *Colors*, *Patterns and Scales*, Krieger Publishing Company, Malabar, Florida.

Bechtel H. B. and Bechtel E. (1981), "Albinism in the snake, *Elaphe obsolete*," *J. Herpetol.*, **15**, 397 – 402.

Boulenger G. A. (1913), *The Snakes of Europe*, Methusen & Co. Ltd., London.

Cassell R. W. and Jones M. P. (2005), "Syntopic occurrence of the erythristic morph of *Plethodon cinereus* and *Notophtalmus viridescens* in Pennsylvania," *Northeast. Nat.*, **12**, 169 – 172.

Erber J. (1879), "Einen Albino der Aesculapnatter (*Elaphis aesculapii*)," *Verh. Zool.-Bot. Ges. Wien*, **29**, 39 – 40.

Ferri V. and Bettiga M. (1992), "Un caso di albinismo nel Colubro di Esculapio, *Elaphe l. longissima* (Laurenti, 1768)," *Il Naturalista Valtellinese — Atti Mus. civ. Stor. nat. Morbegno*, **3**, 91 – 96.

Fitch H. S. (2001), "Further study of the garter snake, *Thamnophis sirtalis*, in northeastern Kansas," *Sci. Pap. Univ. Kansas Naturhist. Mus.*, **19**, 1 – 6.

Fric Z. F. and Moravec J. (2015), "*Vipera berus* (Linnaeus, 1758) — zmije obecná, " in: Moravec J. (ed.), *Fauna ČR. Plazi — Reptilia*, Academia, Praha.

Galarza J. A., Mappes J., and Valkonen J. K. (2015), "Biogeography of the smooth snake (*Coronella austriaca*): origin and conservation of the northernmost population," *Biol. J. Linn. Soc.*, **144**, 426 – 435.

Gilhen J. (2010), "Erythrism in the Maritime Garter Snake, *Thamnophis sirtalis pallidulus*, in Nova Scotia," *Can. Field Nat.*, **124**, 99 – 103.

Gotmark F. (1994), "Does a novel bright color patch increase or decrease predation? Red wings reduce predation risk in European blackbirds," *Proc. Roy. Soc. B*, **256**, 83 – 87.

Gvozdenović S. and Schweiger M. (2014), "Melanism in *Natrix natrix* and *Natrix tessellata* (Serpentes: Colubridae) from Montenegro," *Ecol. Montenegrina*, **1**, 231 – 233.

Happ J. (1994), "Fund einer Albino-Schlingnatter (*Coronella austriaca austriaca* Laurenti, 1768) auf dem Magdalensberg in Kärnten," *Carinthia II*, **184**, 123 – 129.

Hopkins P. W. (1976), "A melanistic Spanish smooth snake (*Coronella a. austriaca*)," *Doñana. Acta Vertebrata*, **3**, 93 – 96.

Jandzík D. (2004), "Partial melanism in the grass snake *Natrix natrix* (Reptilia: Colubridae) from northeastern Slovakia," *Acta Zool. Univ. Comen.*, **46**, 75 – 77.

Kornilios P. (2014), "First report of piebaldism in scolecophidians: a case of *Typhlops vermicularis* (Squamata: Typhlopidae)," *Herpetology Notes*, **7**, 401 – 403.

Krecsák L. (2008), "Albinism and leucism among European Viperinae: a review," *Russ. J. Herpetol.*, **15**(2), 97 – 102.

Kreiner G. (2007), *The Snakes of Europe*, Edition Chimaira, Frankfurt am Main.

Lác J. (1970), "K rozšíreniu a variabilite užovky stromovej (*Elaphe longissima* Laur.)," *Ochrana fauny*, **4**, 19 – 27.

Laňka V. (1978), "Variabilität und biologie der Würfelnatter (*Natrix tessellata*)," *Acta Univ. Carol. Biol.*, **1978**, 167 – 207.

Lauš B. and Burić I. (2012), "Colour abnormalities in *Coronella austriaca* (Laurenti, 1768) in Croatia," *Hyla*, **2012**, 43 – 44.

Lenders A. J. W. (1989), "Partieel albinisme bij een gladde slang (*Coronella austriaca* Laur.)," *Natuurhist. Maandblad*, **78**, 102 – 103.

Lenders A. J. W. (2008), "Opnieuw een albino Gladde slang in de Meinweg," *Natuurhist. Maandblad*, **97**, 139.

Majerus M. E. N. (1998), *Melanism*: *Evolution in Action*, Oxford Univ. Press, Oxford.

Martínez-Silvestre A., Soler J., Gener J. M., García M., and Marti C. (2009), "Albinismo total de *Coronella girondica* en la Península Ibérica," *Bol. Acos. Herpetol. Esp.*, **20**, 44 – 45.

Meijide M. and Peréz-Melero J. M. (1994), "Nuevos casos de melanismo en *Coronella austriaca* y *Natrix natrix* (Ophidia, Colubridae) en al norte de Iberia," *Bol. Acos. Herpetol. Esp.*, **5**, 33 – 36.

Menjón N. (2011), "Caso de albinismo total en *Rhinechis scalaris*," *Bol. Acos. Herpetol. Esp.*, **22**, 78 – 79.

Mezzasalma M., Dall'Asta A., Loy A., Cheylan M., Lymberakis P., Zuffi M. A. L., Tomović L., Odierna G., and Guarino F. M. (2015), "A sisters' story: comparative phylogeography and taxonomy of *Hierophis viridiflavus* and *H. gemonensis* (Serpentes, Colubridae)," *Zool. Scripta*, **44**, 495 – 508.

Mollov I. (2012), "Another case of melanism in the Grass snake *Natrix natrix* (Linnaeus, 1758) (Reptilia: Colubridae) from Bulgaria," *ZooNotes*, **28**, 1 – 3.

Mooi R. D., Wiens J. P., and Casper G. S. (2011), "Extreme color variation within populations of the Common Gartersnake, *Thamnophis sirtalis*, in central North America, with implications for subspecies status," *Copeia*, **2011**, 187 – 200.

Moore J. D. and Ouellet M. (2014), "A review of colour phenotypes of the Eastern Red-backed Salamander, *Plethodon cinereus*, in North America," Can. Field Nat., **128**, 250 – – 259.

Moravec J. (2015), "*Coronella austriaca* Laurenti, 1768 — užovka hladká," in: Moravec J. (ed.), *Fauna ČR. Plazi — Reptilia*, Academia, Praha.

Musilová R., Zavadil V., and Kotlík P. (2006), "Albinismus užovky obojkové," *Živa*, **5**, 228 – 229.

Naumov B. and Tomović L. (2005), "A case of melanism in *Natrix natrix* (Linnaeus, 1758) (Reptilia: Colubridae) in Bulgaria," *Acta Zool. Bulg.*, **57**, 253 – 254.

Niebergall P. (2008), "Fund einer lutinistischen Schlingnatter (*Coronella austriaca*, Lauf)," *Elaphe*, **16**, 62 – 63.

Opatrný E. (1974), "K nálezu melanického exempláře užovky obojkové, *Natrix natrix* (Linnaeus, 1758)," *Acta Univ. Palack. Olomuc. Fac. Rerum Natur.*, **47**, 141 – 144.

Pérez M. and Collado E. (1975), "Hallazgo de *Natrix maura albina*, " *Doñana. Acta Vertebrata*, **2**, 271 – 272.

Pernetta A. P. and Reading C. J. (2009), "Observations of two melanistic smooth snake (*Coronella austriaca*) from Dorset, United Kingdom," *Acta Herpetol.*, **4**, 109 – 112.

Rehák I. (1992), "*Coronella austriaca* Laurenti, 1768 — Užovka hladká," in: Baruš V., Oliva O., Kminiak M., Král B., Opatrný E., Rehák I., Roth P., Špinar Z., and Vojtková L., *Fauna ČSFR. sv. 26. Plazi — Reptilia*, Academia, Praha.

Shine R. and Madsen T. (1994), "Sexual dichromatism in snakes of the genus *Vipera*: A review and a new evolutionary hypothesis," *J. Herpetol.*, **28**, 114 – 117.

Sindaco R., Venchi A., and Grieco C. (2013), *The Reptiles of the Western Palearctic 2. Annotated Checklist and Distributional Atlas of the Snakes of Europe*, *North Africa*, *Middle East and Central Asia*, Soc. Herpetol. Italica, Edizioni Belvedere.

Stegenga B. J. and Mohr J. R. (2012), "*Thamnophis sirtalis sirtalis*, coloration," *Herpetol. Rev.*, **43**, 154.

Sztencel-Jabłonka A., Mazgajski T. D., Bury S., Najbar B., Rybacki M., Bogdanowicz W., and Mazgajska J. (2015), "Phylogeography of the smooth snake *Coronella austriaca* (Serpentes: Colubridae): evidence for a reduced gene pool and a genetic discontinuity in Central Europe," *Biol. J. Linn. Soc.*, **115**, 195 – 210.

Tanaka K. (2009), "Does the thermal advantage of melanism produce size differences in color-dimorphic snakes?" *Zool. Sci.*, **26**, 698 – 703.

Tilley S. G., Lundrigan B. L., and Brower L. P. (1982), "Erythrism and mimicry in the salamander *Plethodon cinereus*," *Herpetologica*, **38**, 409 – 417.

Thurow G. R. (1955), *Taxonomic and Ecological Studies on the Zig-zag Salamander* (Plethodon dorsalis) *and the Redbacked Salamander* (Plethodon cinereus)*. Ph.D. Thesis*, Indiana University, USA.

Venesky M. D. and Anthony C. D. (2007), "Antipredator adaptations and predator avoidance by two color morphs of the eastern red-backed salamander, *Plethodon cinereus*," *Herpetologica*, **63**, 450 – 458.

Vitt L. J. and Caldwell J. P. (2013), *Herpetology — An Introductory Biology of Amphibians and Reptiles. 4th Edition*, Acad. Press.

Werner F. (1893), "Albinismus und Melanismus bei Reptilien und Amphibien," *Verh. Zool.-Bot. Ges. Wien*, **43**, 4 – 6.

Zadravec M. and Lauš B. (2011), "Melanism variations in *Natrix natrix* (Linnaeus, 1758) and *Zamenis longissimus* (Laurenti, 1768) in Croatia," *Hyla*, **2011**, 39 – 42.